

USE OF GIOVANNI SYSTEM IN PUBLIC HEALTH APPLICATION

**2012 GREGORY G. LEPTOUKH ONLINE
GIOVANNI WORKSHOP**

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**Radina P. Soebiyanto^{1,2}
Richard Kiang²**

¹Goddard Earth Sciences Technology & Research
(GESTAR), Universities Space Research Association,
Columbia, MD

² NASA Goddard Space Flight Center, Code 610.2,
Greenbelt, MD

radina.p.soebiyanto@nasa.gov



AGENDA

- **Malaria in Thailand and Afghanistan**
- **Dengue in Indonesia**
- **Avian Influenza in Indonesia**
- **Seasonal Influenza in New York, Arizona and Hong Kong**

MALARIA

■ Cause:

- *Plasmodium* spp (protozoan)
- Carried by *Anopheles* mosquito

■ Burden:

- 250 million cases each year
- 1 million deaths annually
- Every 30 seconds a child dies from malaria in Africa
- Cost ~ 1.3% of annual economic growth in high prevalence countries

- High Risk Group: Pregnant women, children and HIV/AIDS co-infection

Plasmodium
infecting red
blood cell

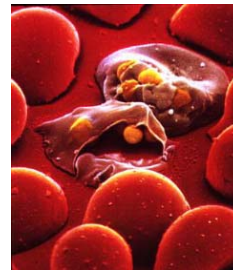
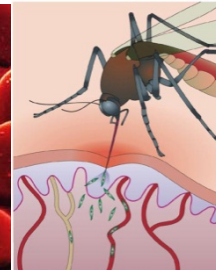


Image: Nat'l Geographic



Transmission
through female
Anopheles bite

Image: Nature

■ Treatment and Prevention:

Bed
nets



Indoor
spraying



Vector
Control



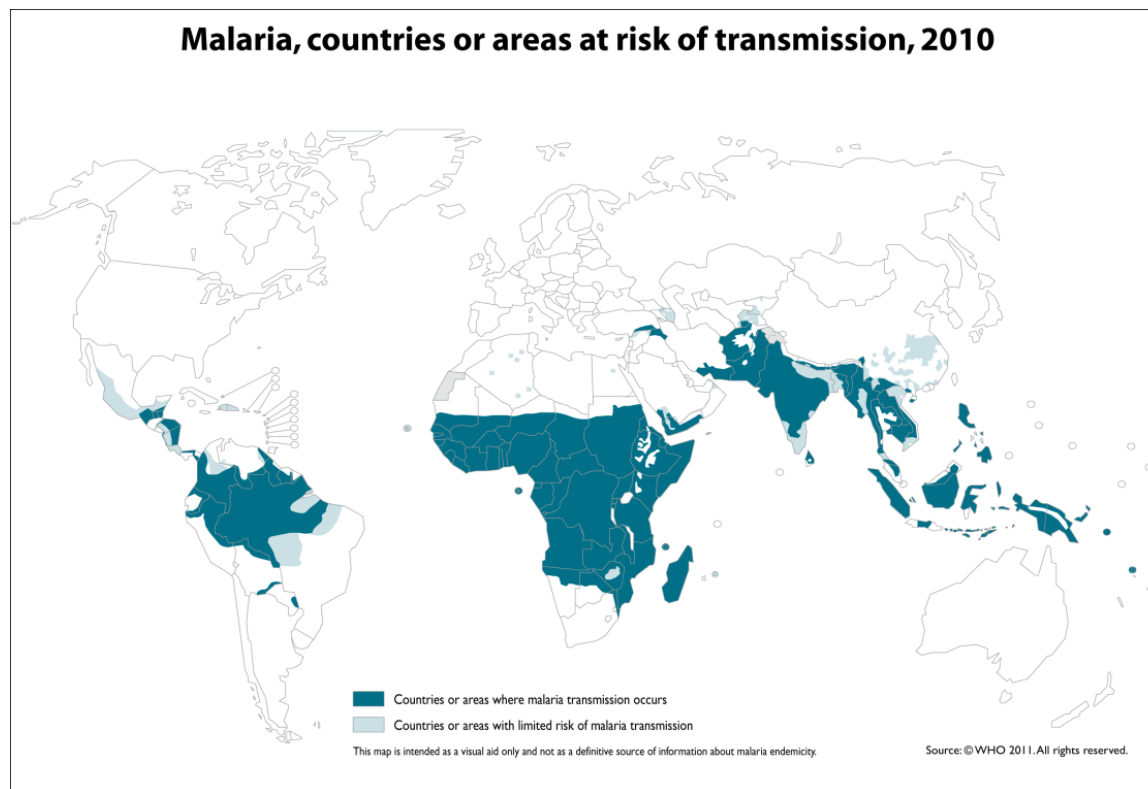
Images: WHO



Artemisin-based
Combination Therapy

MALARIA

Malaria Distribution

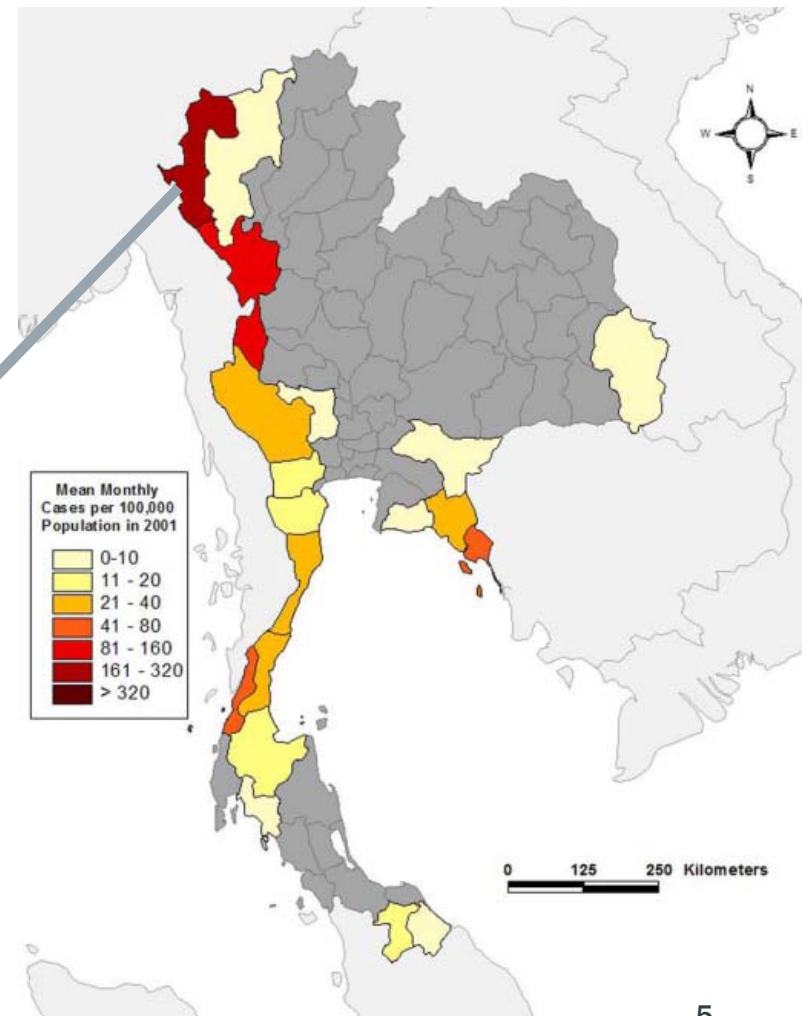
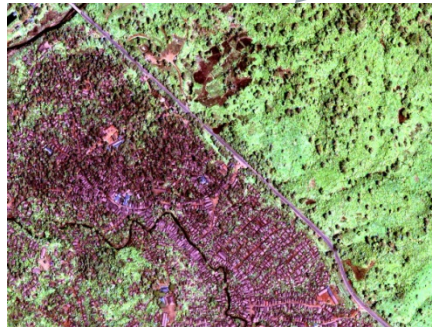


Role of climatic and environmental determinants

Determinants	Effect
Temperature	Parasite + Vector: development and survival
Rainfall	Vector breeding habitat
Land-use, NDVI	Vector breeding habitat
Altitude	Vector survival
ENSO	Vector development, survival and breeding habitat

MALARIA IN THAILAND

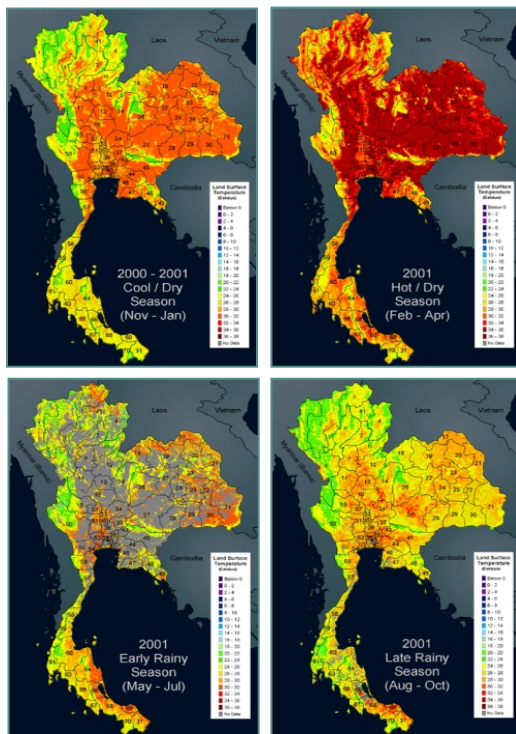
- Leading cause of morbidity and mortality in Thailand
- ~50% of population live in malarious area
- Most endemic provinces are bordering Myanmar & Cambodia
 - Significant immigrant population
 - Mae La Camp
 - Largest refugee camp
 - >30,000 population



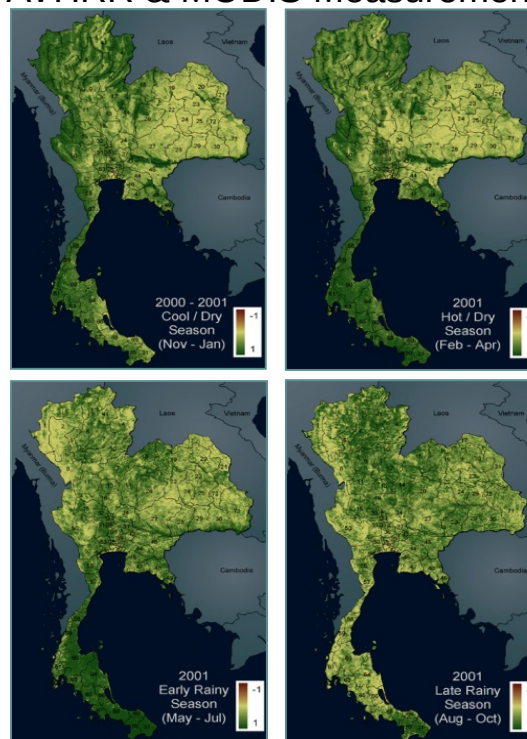
MALARIA IN THAILAND

■ Satellite-observed meteorological & Environmental Parameters for 4 Thailand seasons

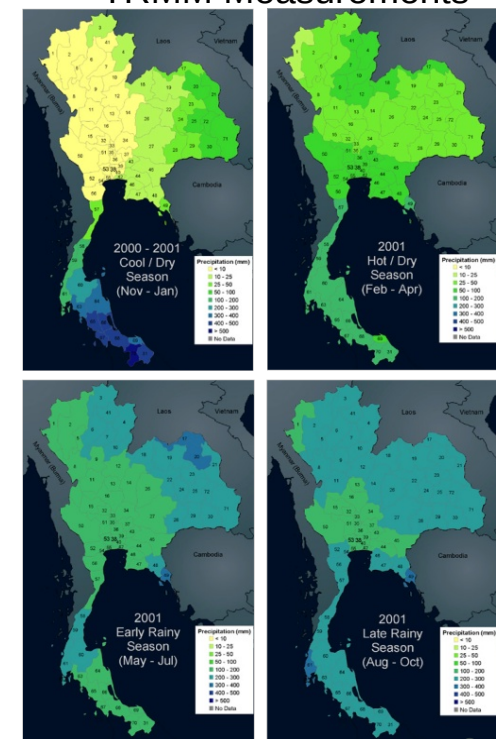
Surface Temperature
MODIS Measurements



Vegetation Index
AVHRR & MODIS Measurements



Rainfall
TRMM Measurements

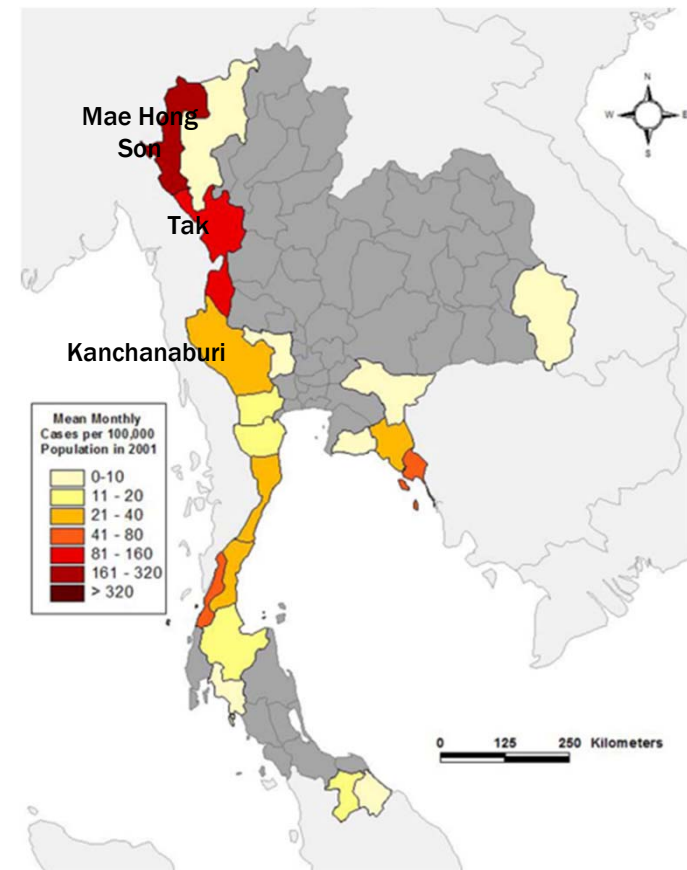
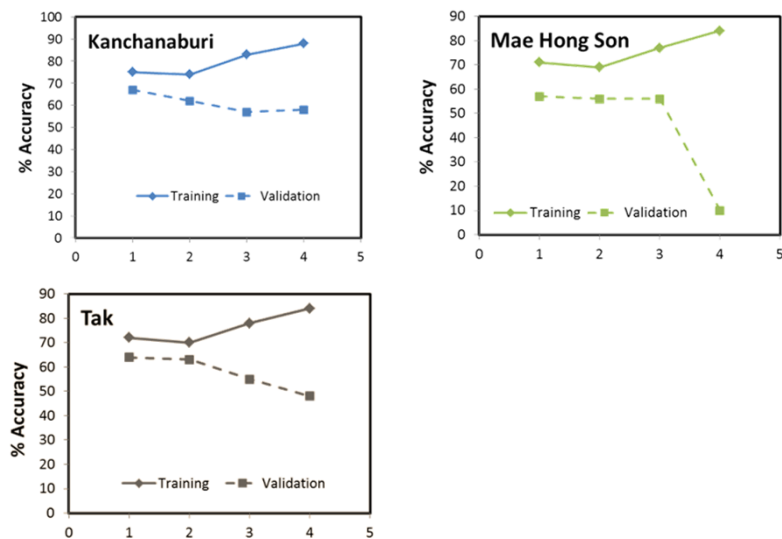


MALARIA IN THAILAND

■ Neural Network training and validation accuracy

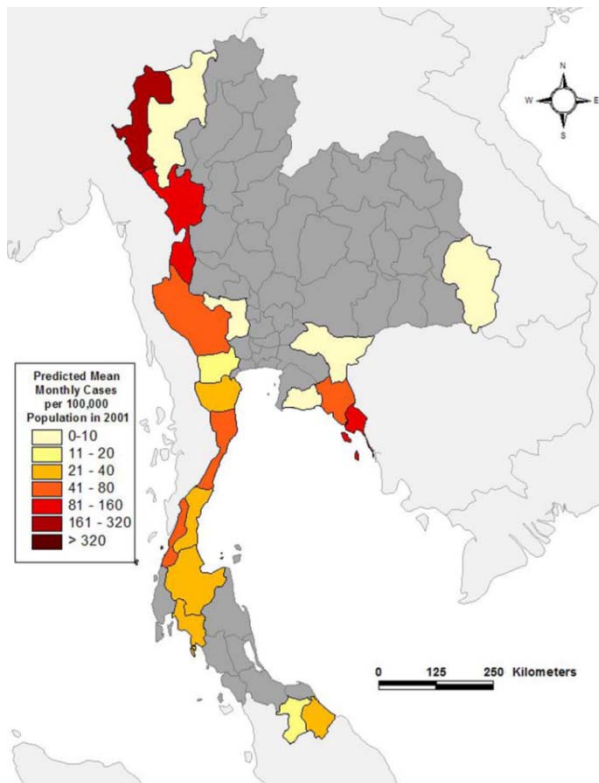
	Input	Hidden Layer	Hidden Node
Model 1	t, T, P, P (lag 1), H, V	1	1
Model 2	t, P, P (lag 1), H, V	1	1
Model 3	t, T, P, P (lag 1), H, V	1	2
Model 4	t, T, P, P (lag 1), H, V	1	3

t = time, T = temperature, P = precipitation, H = humidity, V = NDVI

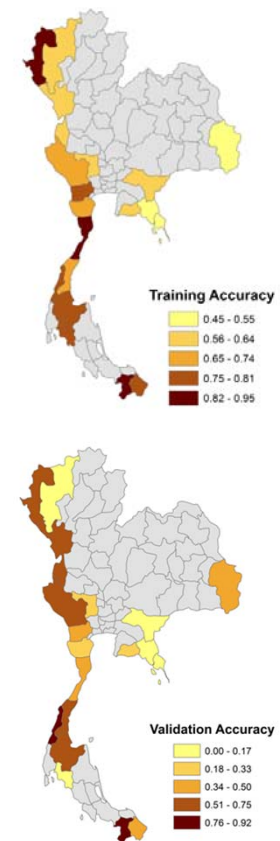
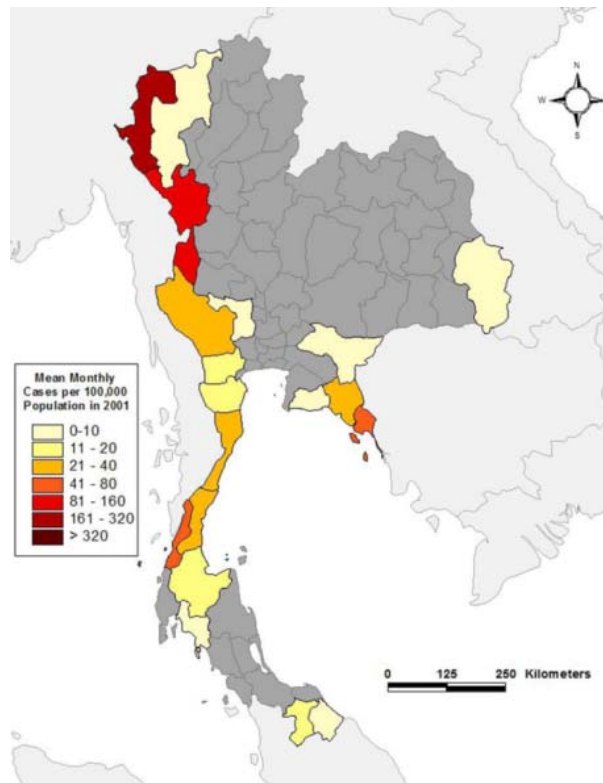


MALARIA IN THAILAND

Hindcast Incidence



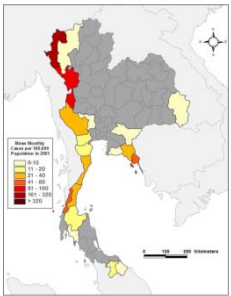
Actual Malaria Incidence



MALARIA IN THAILAND

AGENT-BASED SIMULATION

- Kong Mo Tha (KMT) village, Kanchanaburi
- In Collaboration with AFRIMS and WRAIR
- Malaria surveillance study (1999 – 2004)
 - Blood films from ~450 people per month
 - Larval and adult mosquito collection



A. sawadwongpori, *A. maculatus*



A. dirus



A. barbirostris, *A. campestris*



A. minimus, *A. maculatus*

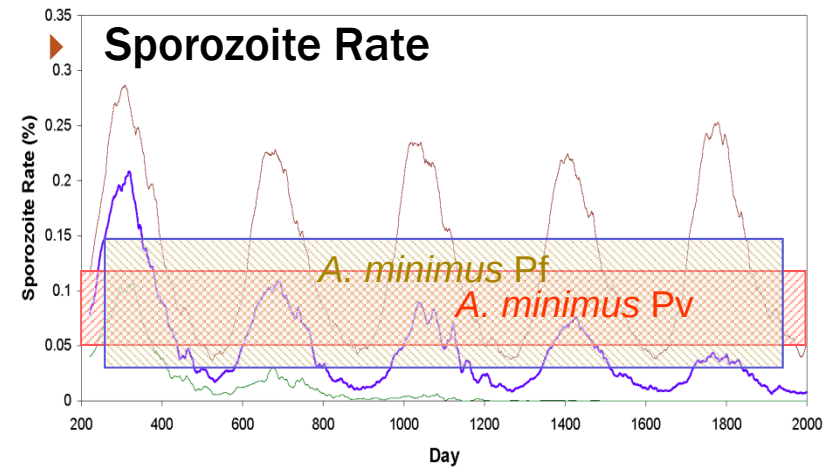
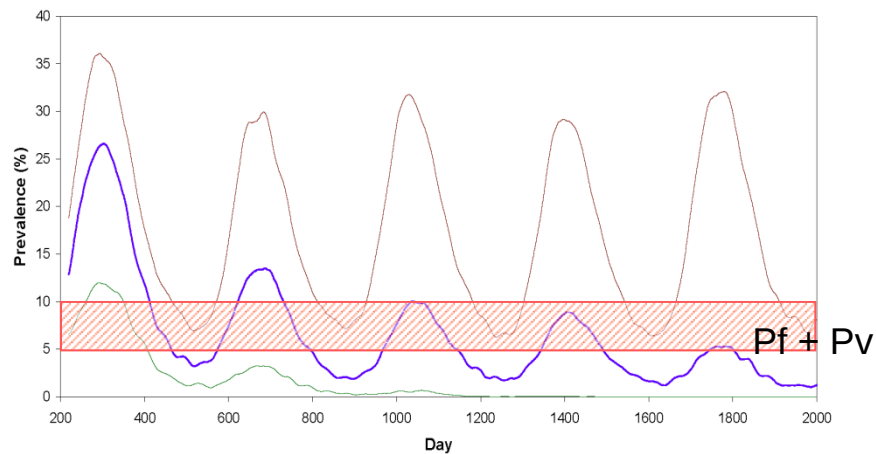
MALARIA IN THAILAND AGENT-BASED SIMULATION

■ A small hamlet example

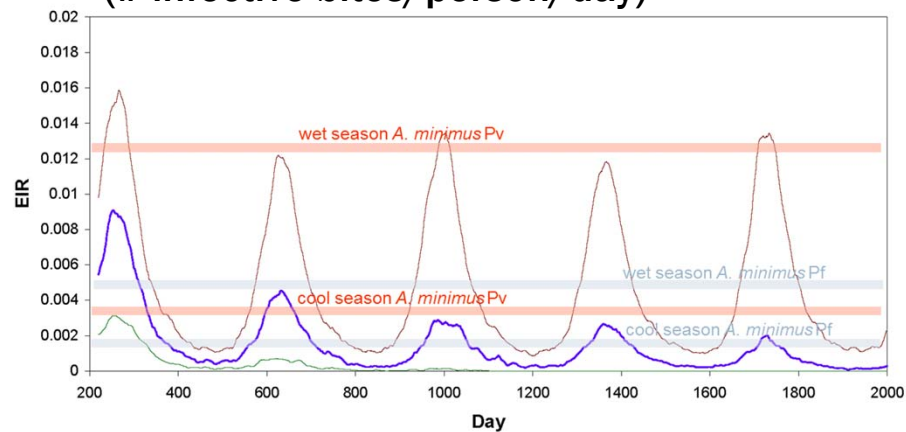


MALARIA IN THAILAND AGENT-BASED SIMULATION

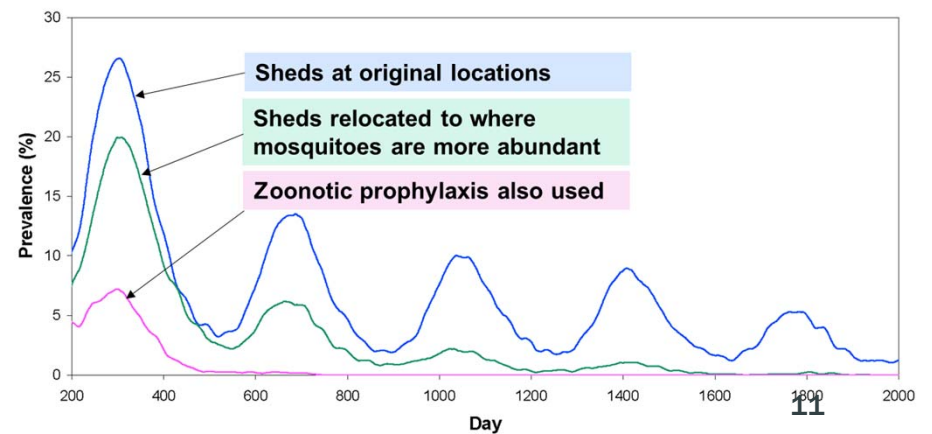
■ Prevalence



► Entomological Inoculation Rate (# infective bites/person/day)



► Scenario analysis



MALARIA IN AFGHANISTAN



MALARIA
JOURNAL

Open Access

Farida Adimi^{1,2}, Radina P Soebiyanto^{1,3}, Najibullah Safi⁴ and Richard Kiang*¹

Background: Malaria is a significant public health concern in Afghanistan. Currently, approximately 60% of the population, or nearly 14 million people, live in a malaria-endemic area. Afghanistan's diverse landscape and terrain contributes to the heterogeneous malaria prevalence across the country. Understanding the role of environmental variables on malaria transmission can further the effort for malaria control programme.

Adimi et al. *Malaria Journal* 2010, **9**:125

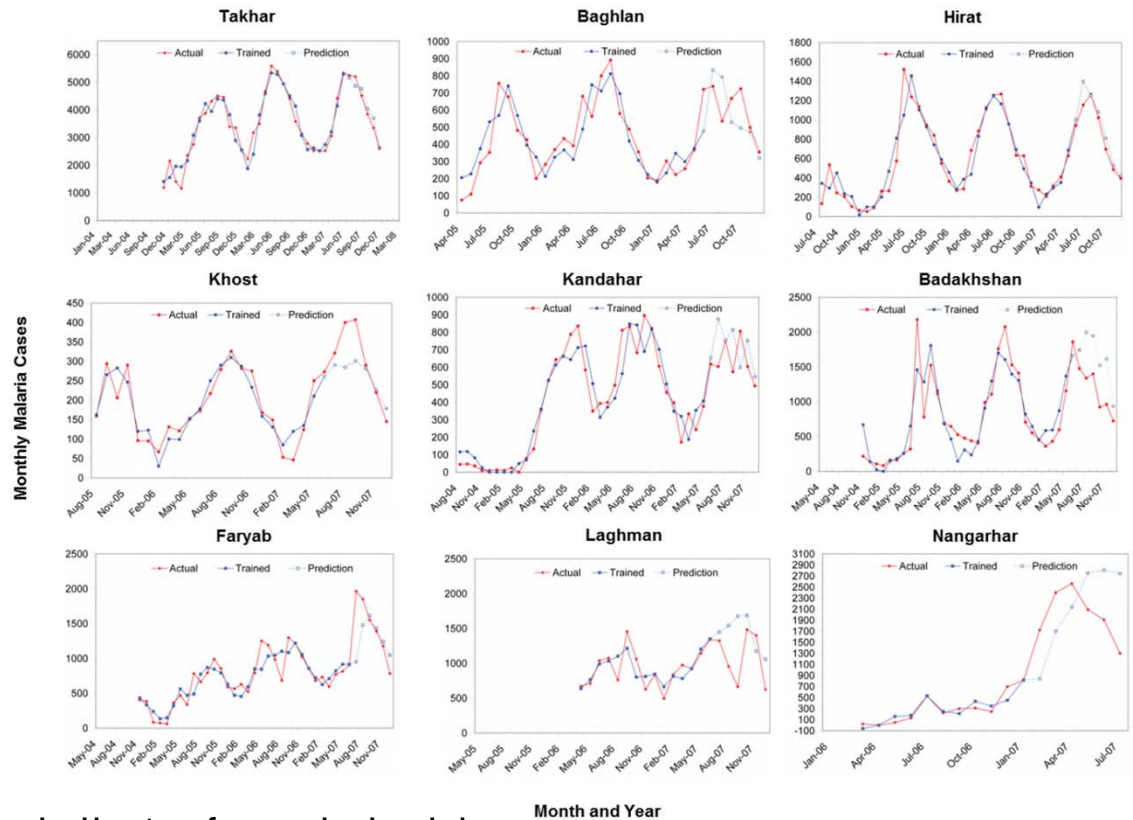
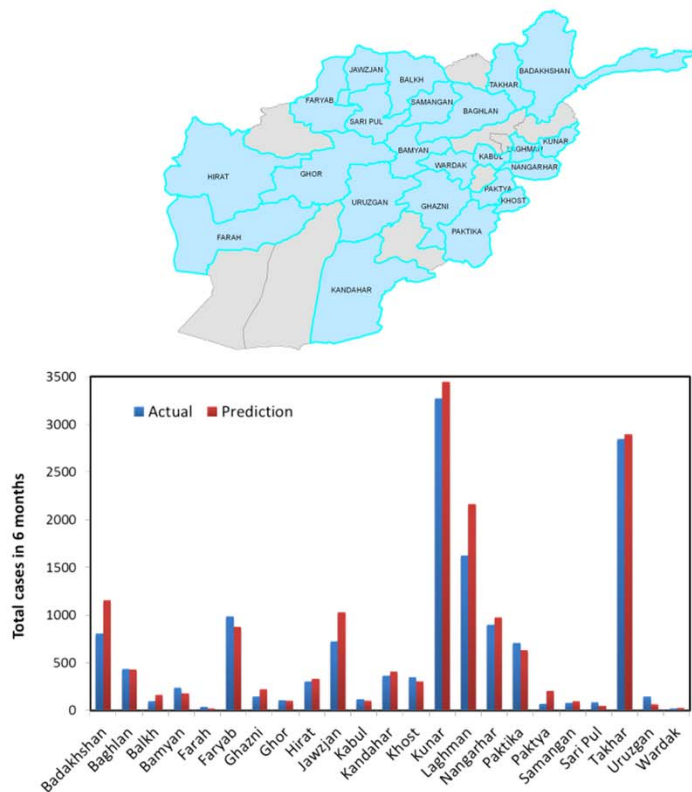
A map of Afghanistan showing its provinces and districts. The provinces are labeled in all caps: JALALIYABAD, BALKH, BACAKHSHAN, FARJAB, SAMANGAN, TASHAR, BARIK PUL, BAHGLAN, BAMIYAN, URGHJ, FURUS, HARID, NANGARHAR, GHOR, WARDAK, PAKTYA, KHOSH, URUZGAN, GHAZNI, PAKTIKA, FARAH, and KANDAHAR. The map uses a color scheme where most provinces are light blue, while some are light green (e.g., BACAKHSHAN, FARJAB, BARIK PUL, URGHJ, HARID, NANGARHAR, PAKTYA, KHOSH, PAKTIKA, KANDAHAR) and others are light orange (e.g., TASHAR, BAHGLAN, WARDAK, GHAZNI).

A map of the Amazon basin showing MODIS-LST (MODIS Land Surface Temperature) data. The map is color-coded, with a legend in the bottom right corner indicating a range from -19.17 to 63.55 degrees Celsius. The colors transition from blue (cooler) to yellow and orange (warmer). The Amazon River and its tributaries are visible, flowing from the west towards the east. The map is titled 'MODIS-LST' in large, bold, black letters at the top.

NDVI

High : 0.887
Low : -0.191

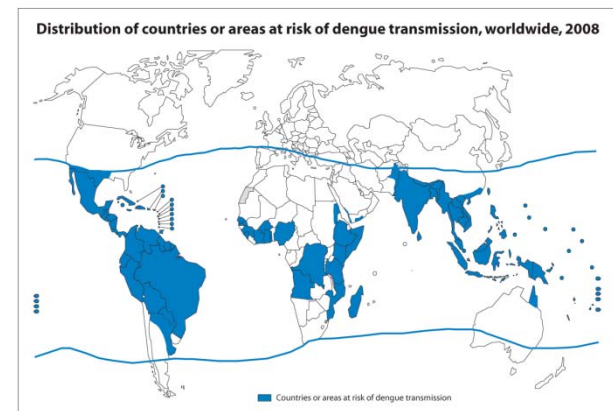
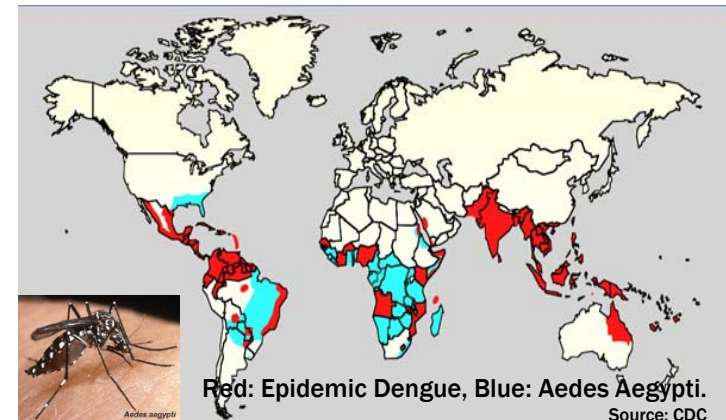
MALARIA IN AFGHANISTAN



- NDVI and temperature were a strong indicator for malaria risk
- Precipitation is not a significant factor → Malaria risk is mainly due to irrigation as implied from the significant contribution from NDVI
- Average R^2 is 0.845
- Short malaria time series (<2 years) pose a challenge for modeling and prediction

DENGUE

- Endemic in more than 110 countries
 - Tropical, subtropical, urban, peri-urban areas
- Annually infects 50 – 100 million people worldwide
- 12,500 – 25,000 deaths annually
- Symptoms: fever, headache, muscle and joint pains, and characteristic skin rash (similar to measles)
- Primarily transmitted by *Aedes* mosquitoes
 - Live between 35° N - 35° S latitude, >1000m elevation
- Four serotypes exist
 - Infection from one serotype may give lifelong immunity to that serotype, but only short-term to others
 - Secondary infection increases the severity risk



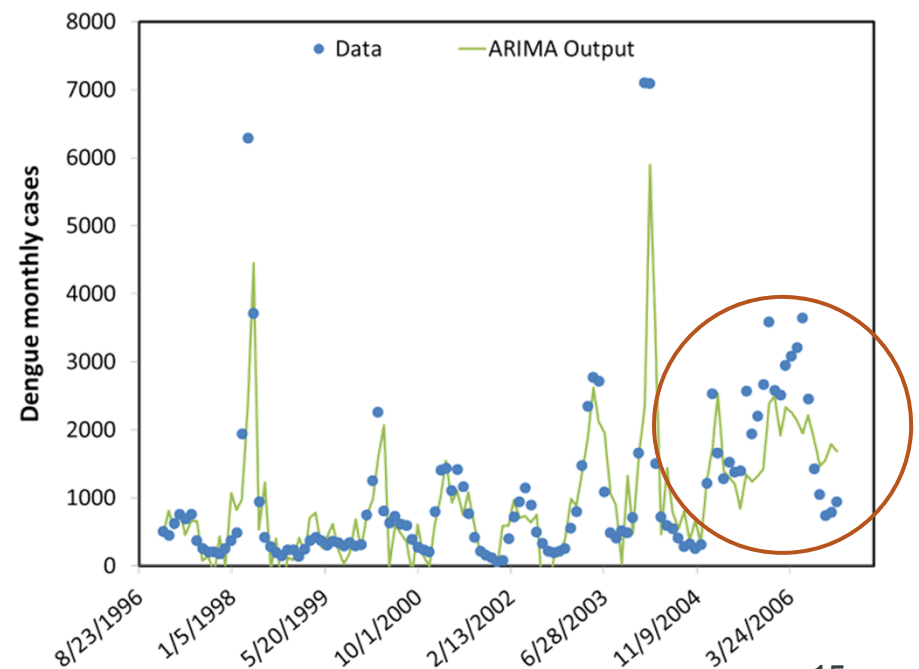
The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its borders or boundaries. Dotted lines on maps represent approximate border lines for which there may not yet be full agreement. © WHO 2010. All rights reserved.

Data Source: World Health Organization
Map Production: Control of Neglected
Tropical Diseases (CNTD)
World Health Organization



DENGUE IN INDONESIA

- **Environmental variables used**
 - Temperature, dew point, wind speed, TRMM, NDVI
- **Modeling method**
 - ARIMA – Auto Regressive Integrated Moving Average
 - Classical time series regression
 - Accounts for seasonality
- **Result**
 - Best-fit model uses TRMM and Dew Point as inputs
 - Peak timing can be modeled accurately up to year 2004
 - Vector control effort by the local government started in the early 2005



AVIAN INFLUENZA

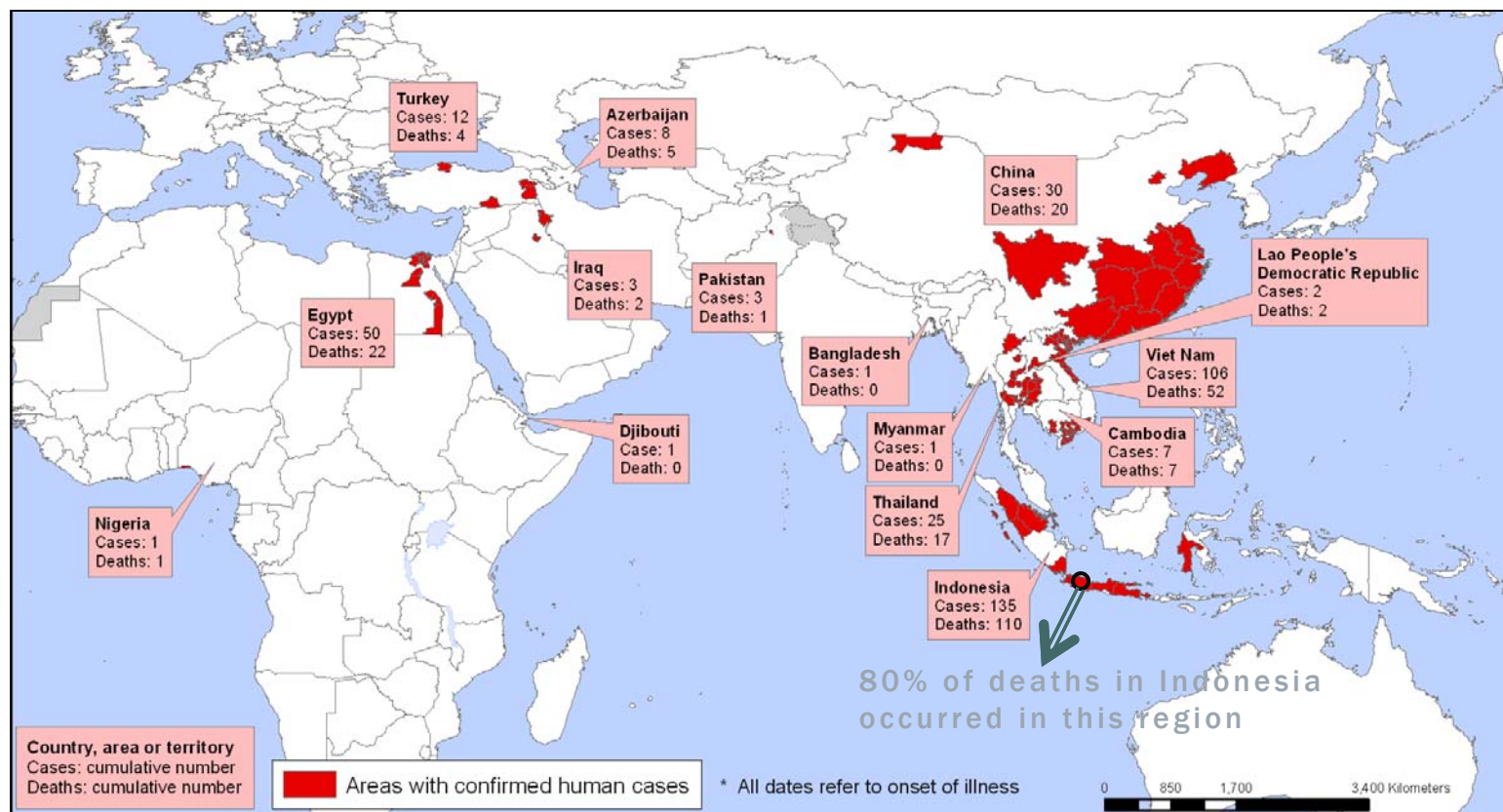
■ The problem

- First appeared in Hong Kong in 1996-1997, HPAI has spread to approximately 60 countries. More than 250 million poultry were lost.
- 35% of the human cases are in Indonesia. Worldwide the mortality rate is 53%, but 81% in Indonesia. In Indonesia, 80% of all fatal cases occurred in 3 adjacent provinces.
- Co-infection of human and avian influenza in humans may produce deadly strains of viruses through genetic reassortment.
- HPAI H5N1 was found in Delaware in 2004.
- The risk of an H5, H7 or H9 pandemic is not reduced or replaced by the 2009 H1N1 pandemic.



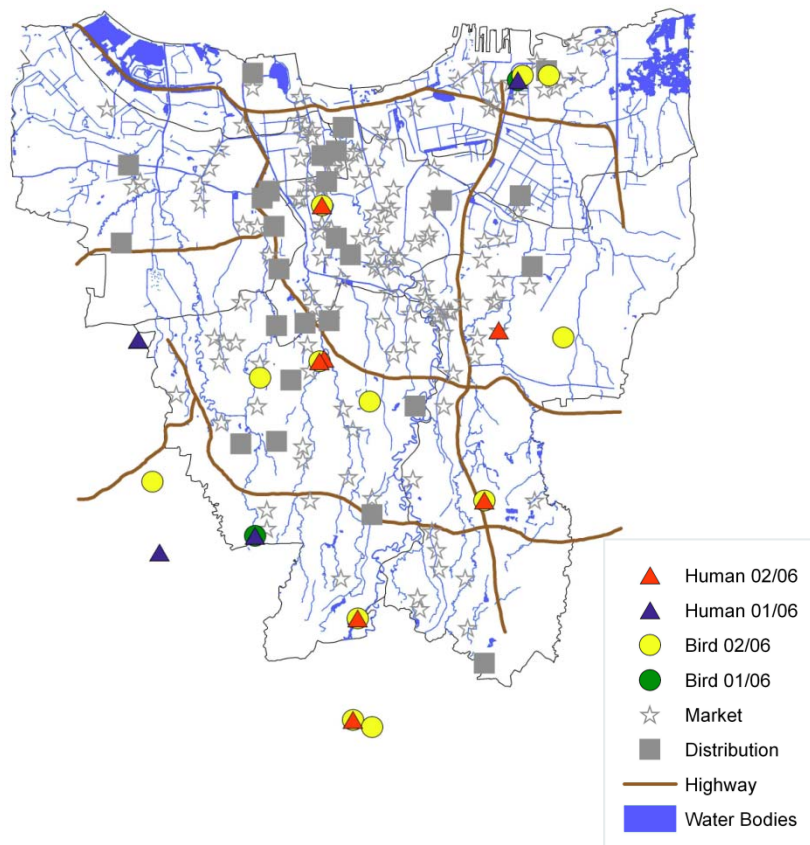
AVIAN INFLUENZA

Indonesia has 35% of the world's human cases with 81% mortality. For the rest of the world, mortality is 53%

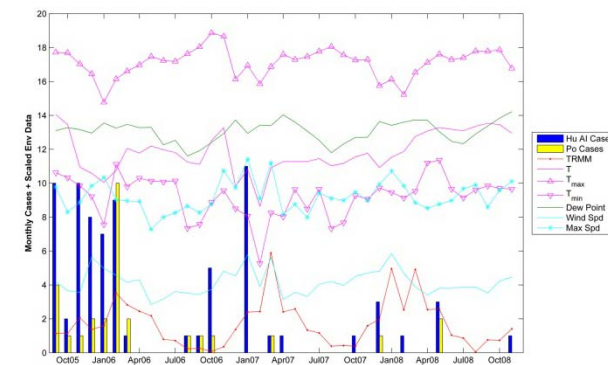


AVIAN INFLUENZA

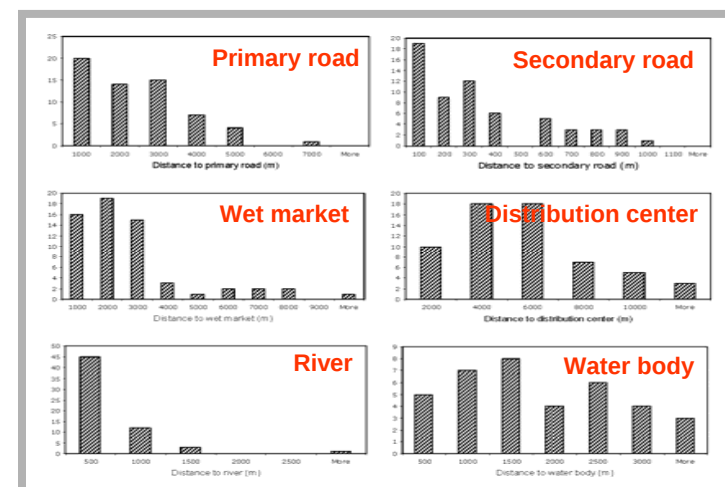
■ Poultry and human outbreaks in Greater Jakarta



■ Cases vs Meteorological factors

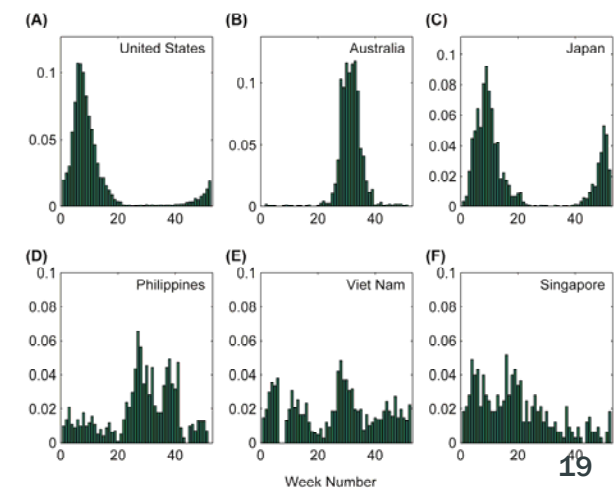
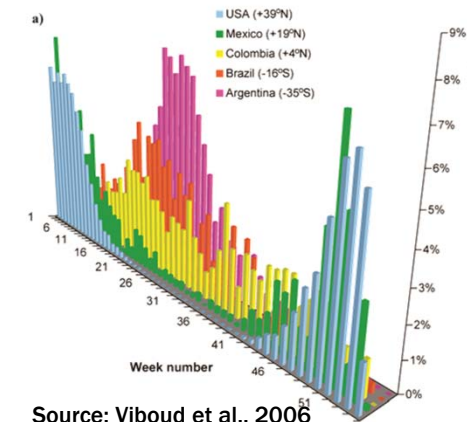


■ Distance from outbreaks



SEASONAL INFLUENZA

- Worldwide annual epidemic
 - Infects 5 – 20% of population with 500,000 deaths
- Economic burden in the US
~US\$87.1billion
- Spatio-temporal pattern of epidemics vary with latitude
 - Role of environmental and climatic factors
- Temperate regions: distinct annual oscillation with winter peak
- Tropics: less distinct seasonality and often peak more than once a year

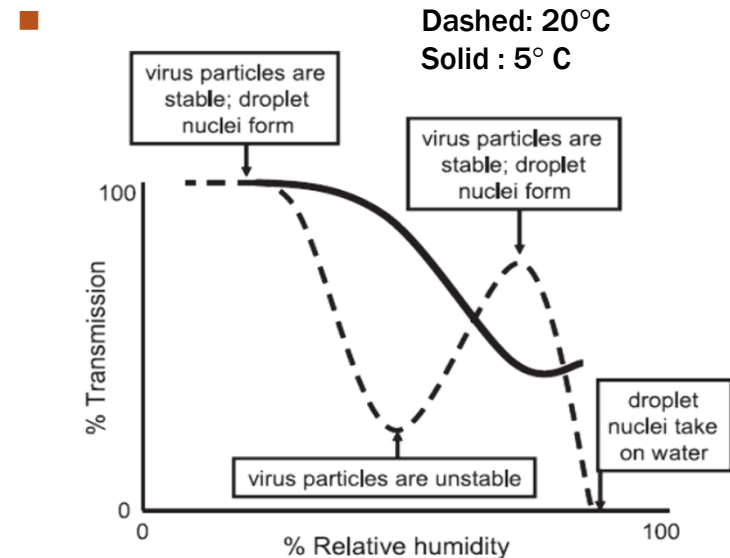


SEASONAL INFLUENZA

■ Factors implicated in influenza

Influenza Process	Factors	Relationship
<i>Virus Survivorship</i>	Temperature	Inverse
	Humidity	Inverse
	Solar irradiance	Inverse
<i>Transmission Efficiency</i>	Temperature	Inverse
	Humidity	Inverse
	Vapor pressure	Inverse
	Rainfall	Proportional
	ENSO	Proportional
<i>Host susceptibility</i>	Air travels and holidays	Proportional
	Sunlight	Inverse
	Nutrition	Varies

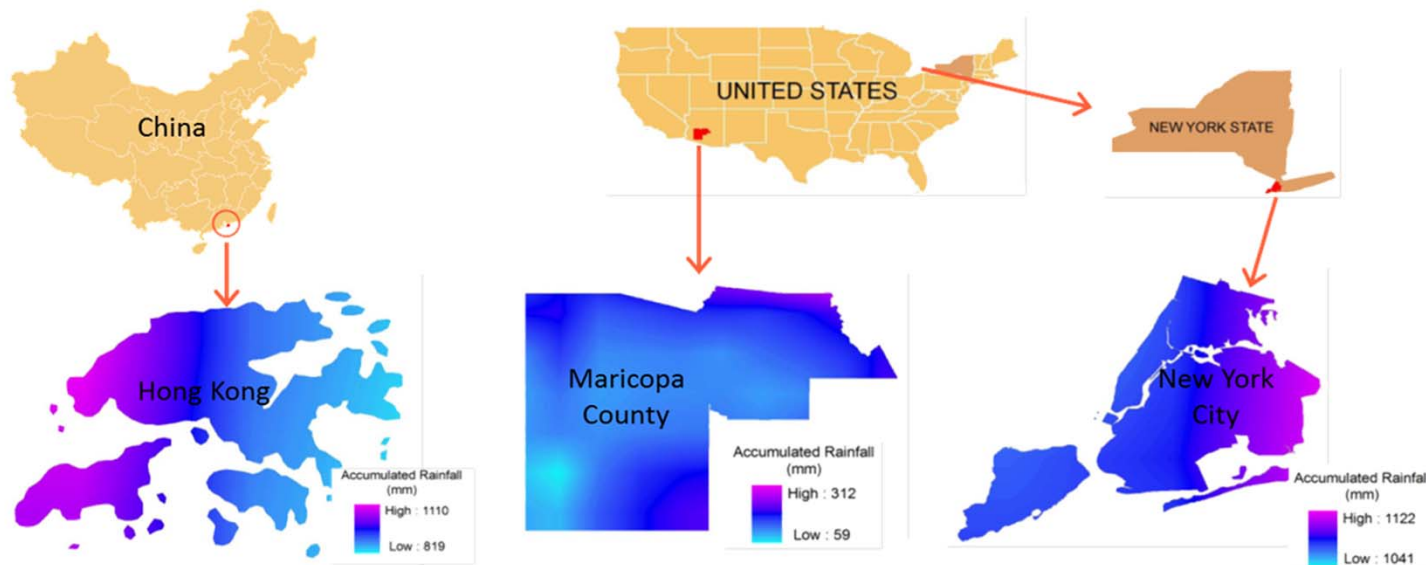
■ *Ex Vivo* study showing efficient transmission at dry and cold condition [Lowens et al., 2007]



■ High temperature (30°C) blocks aerosol transmission *but not contact transmission*

SEASONAL INFLUENZA

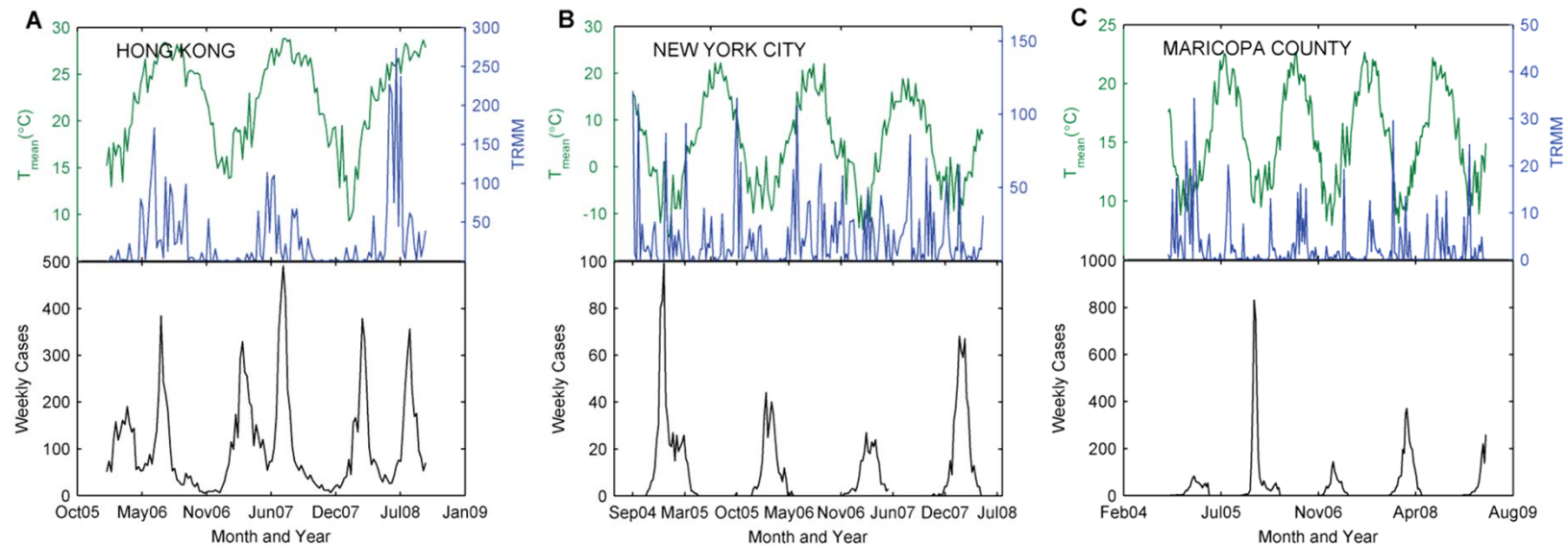
	Hong Kong, China	Maricopa County, AZ	New York City, NY
Center Lat.	22° N	33° N	40° N
Climate	Sub-Tropical	Sub-Tropical	Temperate
General Condition	Hot & humid during summer. Mild winter, average low of 6°C	Dry condition. Mean winter low is 5°C, and summer high is 41°C	Cold winter, average low of -2°C. Mean summer high is 29°C



SEASONAL INFLUENZA

DATA

- Weekly lab-confirmed influenza positive
- Daily meteorological data were aggregated into weekly
- Satellite-derived data
 - TRMM 3B42
 - LST - MODIS
- Ground station data



SEASONAL INFLUENZA

- Several techniques were employed, including:

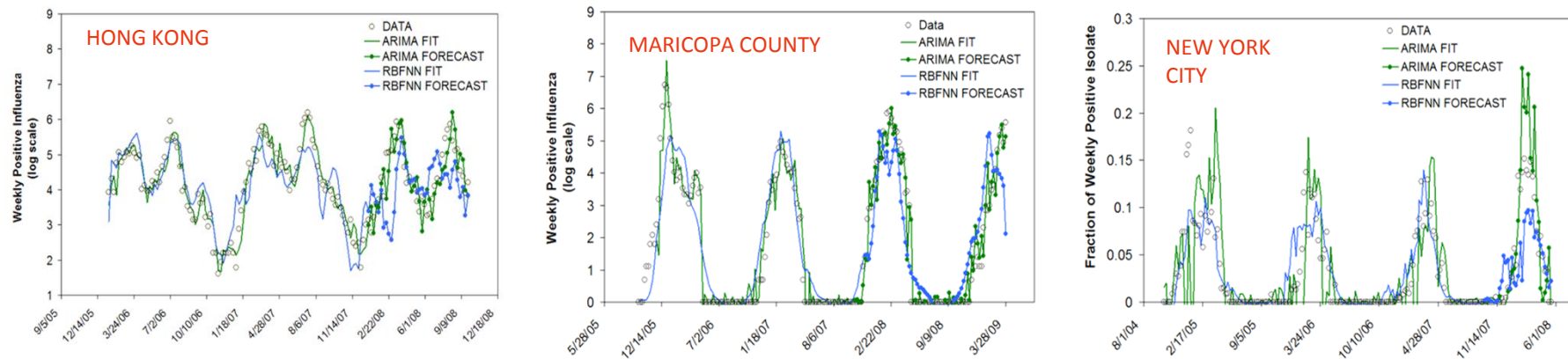
ARIMA (AutoRegressive Integrated Moving Average)

- Classical time series regression
Accounts for autocorrelation and seasonality properties
- Climatic variables as covariates
- Previous week(s) count of influenza is included in the inputs
- Results published in PLoS ONE 5(3): 9450, 2010

Neural Network (NN)

- Artificial intelligence technique
- Widely applied for
 - approximating functions,
 - Classification, and
 - pattern recognition
- Takes into account nonlinear relationship
- Radial Basis Function NN with 3 nodes in the hidden layer
- Only climatic variables and their lags as inputs/predictors

SEASONAL INFLUENZA



- NN models show that ~60% of influenza variability in the US regions can be accounted by meteorological factors
- ARIMA model performs better for Hong Kong and Maricopa
 - Previous cases are needed
 - Suggests the role of contact transmission
- Temperature seems to be the common determinants for influenza in all regions

ACKNOWLEDGMENT

- **NAMRU-2**
- **Wetlands International Indonesia Programme**
- **Cobbs Indonesia**
- **USDA APHIS**
- **WHO SEARO**
- **WRAIR**
- **AFRIMS**
- **Thailand Ministry of Public Health**
- **NDVECC**
- **Mahidol University, Faculty of Tropical Medicine**
- **Safi Najibullah – Formerly at National Malaria and Leishmaniasis Control Programme, Afghan Ministry of Public Health**
- **CDC Influenza Division**

THANK YOU